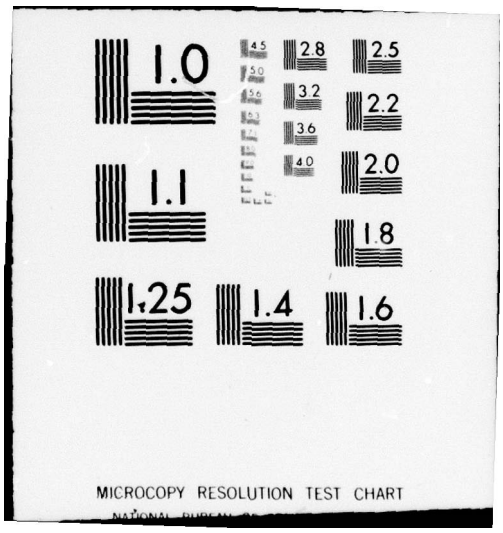
AD-A079 182 ARMY PERSONNEL RESEARCH OFFICE WASHINGTON DC F/G 5/9
HUMAN FACTORS PROBLEMS IN THE DEVELOPMENT AND USE OF IMAGE INTE--ETC(U)
MAY 66 G F BIGELOW
UNCLASSIFIED APRO-RESEARCH STUDY-66-4 NL

| OF |
AD A
079182

END
DATE
FILMED
2 -80
DDC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART

LEVEL II

AD A079182

Research Study 66-4

HUMAN FACTORS PROBLEMS IN THE DEVELOPMENT AND USE OF IMAGE INTERPRETATION KEYS

May 1966

DDC
RECEIVED
DEC 26 1979
A

DDC FILE COPY

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

U. S. ARMY PERSONNEL RESEARCH OFFICE

79 12 19 186

Army Project Number
2J620901A721

Displays b-10

(14) APRO — Research Study 66-4

(6) HUMAN FACTORS PROBLEMS IN THE DEVELOPMENT AND USE OF IMAGE INTERPRETATION KEYS,

(10) By George F. Bigelow

Abraham H. Birnbaum, Task Leader

Submitted by

Joseph Zeidner, Chief
Support Systems Research Laboratory

(12) 26

Approved by

J. E. Uhlaner
Director of Laboratories

Accession For
NTIS GRA&I
DDC TAB
Unannounced
Justification
By
Distribution/
Availability Codes
Dist | Avail and/or special
A

U. S. ARMY PERSONNEL RESEARCH OFFICE

Office, Chief Research and Development
Department of the Army

Washington, D. C. 20315

(11) May 1966

Research Studies are special reports to military management. They are usually prepared to meet requests for research results bearing on specific management problems. A limited distribution is made--primarily to the operating agencies directly involved.

040 650

HUMAN FACTORS PROBLEMS IN THE DEVELOPMENT AND USE OF IMAGE INTERPRETATION KEYS

BRIEF

REQUIREMENT:

Image interpretation keys are at present the primary reference used by interpreters. Reference keys differ in concept, scope, content, and organization. Interpreters differ in their need for such references and in the way they use them. Research is needed to develop keys of optimum value to the military user and procedures for their optimal use in both manual and automated image interpretation facilities.

PROCEDURE:

The purposes for which keys are used, the kinds of keys maintained in the central reference store and in separate smaller image interpretation facilities, and the ways in which keys are used by trainees and operational personnel were examined. Military and civilian experts in the intelligence community were consulted. The literature of research on image interpreter use of reference aids and related subjects was searched. An array of problems encountered in the preparation and use of reference keys was formulated.

PRODUCT OF THE STUDY:

The problems were analyzed and restructured in terms of three sets of factors entering into the problem situations: (1) factors of output--speed, accuracy, and completeness of interpretation--by which the effectiveness of a procedure, an instrument, or a system is assessed; (2) factors entering into conditions under which keys are used; and (3) factors representing variations in the keys themselves.

UTILIZATION OF RESULTS:

The categorization of factors relating to reference keys and their use constitutes the framework for a series of research studies now under way or being formulated. The studies are designed to result in more compact and effective keys for use in both manual image interpretation systems and the computerized facilities now in the developmental stage.

HUMAN FACTORS PROBLEMS IN THE DEVELOPMENT AND USE OF IMAGE INTERPRETATION KEYS

The U. S. Army Personnel Research Office is conducting research on image interpretation systems, with particular emphasis on man-machine interactions within these systems. Army tactical requirements for the future stress the need for comprehensive reconnaissance, using not only conventional cameras but also panoramic cameras, side-looking radar, and infrared sensors. For this reconnaissance to be truly effective, it must be supported by a strong capability for extracting and correlating accurate and complete intelligence information from the records of the various sensors. This extremely critical and responsible work is the major responsibility of the Army image interpreter.

As the Army gradually acquires more sophisticated systems for interpreting the imagery produced by the newer sensors and new developments in aerial photography, the image interpreter will need to utilize special viewing devices and techniques, mensuration instruments, and reporting equipment even more than he does now. In addition, he will need to have at his disposal a wider variety of stored reference aids such as area maps and charts, earlier photo coverage, area photo interpretation reports, and intelligence studies. Of these reference aids, the so-called photo interpretation key--now extensively used by interpreters--may have great utility to the future interpreter working in an automated tactical image interpretation facility.

"A photo interpretation key is reference material designed to facilitate rapid and accurate identification and determination of the significance of objects or terrain conditions from analysis of their photo images." This definition appears in the Interservice Photographic Interpretation Handbook as issued in 1954. The definition admits a variety of keys and is applicable to reference components of automatic data processing systems which involve high speed retrieval and display of key materials. No particular format or method of presentation is specified. Keys of various types are defined in the Appendix.

In the present Research Study, the term "photo interpretation key" is replaced by the more general term "image interpretation key" to include imagery produced by such newer sensors as infrared (IR) and side-looking radar (SLAR).

Over the past twenty years, the Armed Forces have compiled a large family of these image interpretation keys. With a few exceptions, the keys consist of bound volumes containing selected illustrations with explanatory text. Despite the considerable production of keys over a period of years and their extensive use in training and operational image interpretation, the current favorable evaluation of keys as a technique of interpretation has been reached primarily through individual judgments.

Little empirical knowledge exists as to whether keys serve their intended purposes or to what degree they are useful in given situations. These and related problem areas demand fuller exploration.

OBJECTIVE

The objective of the present study was to define problems inherent in the use of keys and to indicate research approaches by which the utility of keys may be established empirically. The fundamental purpose of keys was examined and reappraised in relation to the Army user, and problems were identified which should be investigated in order to provide evaluative information meeting the needs of Army image interpretation systems still in planning. The problems delineated are concerned with the content, organization, and format of military keys now available and with the use of keys by interpreters. The problem field has been structured to provide a basis for research studies of manageable scope which will provide indications of specific ways in which keys can best be modified to serve present users. The studies are expected also to provide information useful in developing new keys compatible with present and future system capabilities and requirements.

PURPOSES SERVED BY IMAGE INTERPRETATION KEYS

Military image interpretation keys are designed primarily as references which the image interpreter uses to make judgmental comparisons of imagery he is interpreting with imagery that has already been identified, and thus arrive at a decision concerning objects and conditions of which he is doubtful. Image interpretation keys are also used in conjunction with other reference aids in the orientation and indoctrination of image interpreters approaching geographical areas with which they are unacquainted or those reassigned to a new area of specialization. Reference keys also have a well defined function in the training of novice interpreters and students in the Image Interpretation courses at the U. S. Army Intelligence School.

KEYS AS REFERENCES IN OPERATIONAL IMAGE INTERPRETATION

Information extraction from imagery often calls for confirmation through comparison with known photo examples. Image interpretation keys can supply missing pieces of information which often enable the interpreter to complete the picture for the intelligence user. No interpreter is expert in the imagery of every military subject. As Whitmore (1953) pointed out, "There is no such thing as a fully qualified photo interpreter." An image interpreter concentrating on military vehicles may be quite unfamiliar with the appearance of atomic energy installations. When directed to locate any such installations in an area covered by an aerial mission, he logically selects a key dealing with installations for atomic energy research and development. No interpreter knows when in his search of imagery he is going to note an object or situation resembling nothing he

has ever before had occasion to identify. He may recognize an object as belonging to a general class but not be able without the aid of a key to pin down the type as specifically as the intelligence users require. Or he may sight a gun which he cannot identify but which he may remember having seen pictured, or "keyed," in a certain reference volume. Reviewing the reference material may expedite identification of the gun in question.

In a good reference system, keys are combined with charts, diagrams, graphs, and other aids to analysis (Coleman, 1952). An image interpretation key aids in identification of objects and analysis of patterns in imagery (Frost, 1952). If keys are to be effective aids to interpretation, they must be developed and organized so as to meet the requirements of the users. The user, for his part, does not expect the key to supply the answers to all his identification problems. What the interpreter sees on a photograph is often only a clue to far more significant information; identification of such a clue may merely be the first step in the interpretation process.[1] He supplements the information the key provides with his accumulation of experience as an interpreter, his powers of trained observation, and his analytical ability.

KEYS AS ORIENTATION AIDS

Military reference keys make a major contribution not only to identification of objects of military significance but also to the evaluation of their significance. Whitmore (1953) considers keys a means by which intelligence information gathered by an expert in a particular field can be passed readily to those who are much less expert. An experienced image interpreter assigned to extract information from imagery obtained for a geographical area with which he not familiar may rely heavily on appropriate keys. Regional keys would be his primary resource in familiarizing himself with the new area. Without such a resource, the vast differences in physical terrain and in cultural features associated with different regions could be extremely confusing. The usefulness of keys for orientation and indoctrination needs to be evaluated in carefully defined situations in which the key content, format, and organization are systematically varied.

---

[1] Babington-Smith (1957) likens the clue to a rubber ball that bounces into the street in front of a motorist. The driver instinctively applies his brakes, expecting a child to follow the ball. Unless a military interpreter is thoroughly familiar with the pertinent intelligence regarding his area of concern, he may perceive the right clues; but having nothing tangible to relate them to, his chances of reaching the right conclusion as to significance are greatly reduced.

KEYS AS TRAINING AIDS

The Army trainee entering the field of image interpretation finds that, in most of the imagery he views, military objects appear in a completely new configuration. As is pointed out in the Manual of Photographic Interpretation (1960): "Most photo interpretation is done with vertical photographs, and the vertical view presents objects on the earth's surface in an unfamiliar aspect." Oblique photographs also present special problems, although the perspective is more familiar. The Manual also states that, because of the vertical view and small scale, some elements of appearance assume greater importance in aerial photographs than in ground views. These elements, which receive special attention in the interpretation training course, include size, shape, shadow, tone and color, texture, and pattern. Familiarity with these elements is acquired through a study of keys. Training concentrates on objects of tactical interest which are of particular concern to the Army image interpreter, but natural features of the terrain are not neglected, since they will be of direct concern to the trainee in exercises dealing with trafficability and the logical siting of enemy gun positions and billeting areas.

The research problem here is to determine the relative usefulness of keys differing in content and organization for specific training objectives, as well as to estimate the relationship between training reliance on reference keys and ultimate performance as interpreters.

HOW THE IMAGE INTERPRETER USES KEYS

The degree to which the Army image interpreter is able to consult keys to tactical images varies with the tasks he is assigned and the conditions under which he is working. Each type of report is made under different time restrictions, ranging from the extremely high speed requirements of the Spot or "Hot" report (previously called Flash report) through the Immediate report and Mission Review report to the more time-consuming Summary report and Detailed report. When only a few minutes are allowed for reporting, the time allotted for consulting reference keys must be extremely limited, if indeed the interpreter has time to consult them at all. A report made over a period of days, or even of hours, permits a more thorough search of reference materials.

Conditions governing a particular operation will also vary. In larger headquarters, the working area for interpreters may provide unlimited storage space for references. In a van such as the AN/TSQ-43 (TIIF), space is very limited and all space must be used functionally. Keys would perforce be restricted in number, and those requiring minimal storage space would be preferred. Presumably, only those having subject matter closely related to the mission objective of the facility could be stored within the van.

The Army image interpreter in the field is primarily concerned with tactical rather than strategic situations. His greatest need is for good subject and item references relating to military weapons, vehicles, shelters, and other equipment, both open and camouflaged. He may be called on for intelligence information relative to troop movements, and should therefore have reference aids to analysis of terrain conditions and trafficability. He may be required to interpret transportation targets, electronic installations, communications facilities, and other features that tend to overlap the tactical and strategic categories. Such features are treated in military subject keys and to a lesser degree in regional keys as well.

SPECIAL PROBLEMS

Some criticisms directed at the content and organization of existing keys are symptomatic of problems which deserve research attention. Keys have been regarded as having poorly selected content, as being poorly organized and hard to use; as too voluminous, too bulky physically and hard to use; and as containing obsolete materials and containing illustrations of poor quality.

PROBLEMS OF CONTENT

The typical image interpretation key is made up of (1) a collection of annotated or captioned imagery--aerial photos, stereograms, or other images--illustrative of objects or conditions the interpreter is likely to be called on to identify, and (2) a word description or graphic aid which sets forth in systematic fashion the photo-recognition features of the objects or conditions.

Some keys are in effect "picture books." In some, illustrations are limited to ground photos, which are inadequate aids for identifying objects in imagery from aerial reconnaissance. Other keys present a variety of aerial photos of an object taken from different angles and heights. Some have well constructed glossaries and indexes. In others, such reader aids are inadequate or lacking.

Selection of Materials. Photographic illustrations in a key as a rule include vertical views--both small and large scale, selected oblique views, and ground photos. This imagery is supplemented in some keys by maps, charts, and tables showing geographical distribution of weapons and vehicles, terrain, and weather information. Where aerial coverage is inadequate or where none is available, schematic drawings and silhouettes are sometimes substituted.

At present, most illustrations in reference keys are conventional aerial and terrestrial photographs. Hoffman (1960) has stressed the need for radar keys; and Van Lopik (1962) has emphasized the value of both radar and infrared imagery. Radar and infrared imagery is often used to supplement data from aerial photography. A correct interpretation may often be

reached by the convergence of evidence provided by two or more different sensors. In some instances, radar and infrared provided the only sensor record of military objects or activities. It is therefore considered desirable that new keys be produced to make possible fuller exploration of the relatively unfamiliar imagery.

To the basic key content one or more of the following may be added: comparative cover (recommended by Dill, 1959), cycles of activity--clearing a site, construction phases, operational use, and abandonment (Bigelow, 1963), color photographs (McDaniel and Arntz, 1959; and Smith, 1963), and comparable records of other sensors when available and pertinent. Keys may include material on primarily photogrammetric subjects such as underwater depth determination, height determination from shadows, and estimation of the speed of moving vehicles or vessels.

Obsolescence. The problem of obsolescence applies primarily to military subjects rather than to regional keys. Obviously, the characteristic appearance of land forms or vegetation species does not require frequent updating, although it may be necessary to add additional examples to improve or amplify the presentation. On the other hand, subject keys to certain military items do become obsolete--sometimes very suddenly, as did those on Japanese World War II equipment. Bigelow (1963) recommended that keys be assembled in a ring-type binder or even a comb binder rather than in conventional solid binding. The ring binder is now used for Army keys, permitting rapid insertion of new pages under field conditions as old ones become obsolete.

When automated systems are in common use, the problem of obsolescence can be handled by a continuous maintenance program. A service organization would regularly review the materials in the central reference store, purge the files of obsolete items, and replace them with up-to-date material. Supplemental materials for inclusion would be furnished by interpreters in the field, even as today. Items of interest would be forwarded to the cognizant reproduction facility for inclusion in the central store. A field interpreter finding an unfamiliar item of possible interest as reference material should forward complete information to the higher echelon, giving exposure number(s), date, geographic coordinates, and his tentative identification.

Error Keys. Recent experience with performance measures developed by the U. S. Army Personnel Research Office has shown that errors of certain types are frequently made by a number of image interpreters. Such errors may be characteristic of image interpretation under given sets of conditions. A typical example is the tendency of interpreters, especially at scales of about 1 : 10,000, to misidentify a regular pattern of tree shadows falling across a road as a convoy of vehicles. It is not known whether this type of error increases in frequency under near-real time non-stereo viewing conditions.

In a recent experiment, Martinek and Sadacca (1965) studied the effect of "error keys" on image interpreter performance, and concluded that the use of such keys significantly reduced error and increased accuracy. The degree of completeness of the intelligence report was not significantly affected by the use of error keys.

A few keys show examples of camouflaged and dummy or decoy installations to help the interpreter recognize the attempts at deception. It is believed, however, that illustrations of common interpreter errors have not yet been introduced. Human factors studies are needed to obtain more information about common types of error. Findings may then be applied in the development of future image interpretation keys.

QUESTIONS OF ORGANIZATION AND FORMAT

Organization of content varies greatly in the ease with which the desired material can be located. Some subject keys are so arranged that the interpreter selects from a number of items the example corresponding most nearly to the image he is trying to identify. These are known as integrated selective keys. Other subject keys are so arranged that the interpreter follows a prescribed step-by-step procedure that leads to the elimination of all items except the one corresponding most nearly to the one he is trying to identify. These are termed dichotomous keys.

The interpreter selects from available keys the one most directly related to the problem he is trying to solve. If, in his search of imagery he can see immediately that the object to be identified is some sort of vehicle, he is likely to choose a dichotomous subject key to military vehicles. Is the vehicle tracked or wheeled? If the ratio of length to width indicates that it is a tracked vehicle, further investigation of the dichotomous key (with or without a turret, large or small gun barrel) will bring him nearer to a decision. Eventually, location of individual hatchways, machine guns, and other details, doublechecked by careful measurement, can bring him to identification of the exact type of vehicle.

If, however, he is dealing with a completely unfamiliar object, the interpreter will have to go through the eleven-step analysis described in the following table by Seymour (1957) in order either to place the object within a subject area and then reach an identification or eliminate the object as being without military significance.

STEPS IN THE ANALYSIS OF UNIDENTIFIED INFORMATION	
Step	Activities
1	Approach each task as of grave concern.
2	Limit study to areas of concern to the user.
3	Test the photograph for practical photogrammetric values.
4	Plan interpretation sequence and concentrate on observable clues, temporarily foregoing deduction.
5	Annotate boundary limits of each selected site.
6	Measure, describe, and identify general function categories.
7	Subdivide the general site by further annotation of particular features.
8	Measure, describe, and identify sub-categories insofar as supported by test.
9	Isolate unidentified features and seek additional clues.
10	Complete remaining factual organization.
11	Re-attack remaining unidentified features in terms of accumulated evidence of general or particular relationships.

The study by DeLancie and Steen (1957) was an early attempt to evaluate quantitatively the effect of reference keys. Emphasis was on comparing results when interpreters used dichotomous keys and when they used integrated selective keys. A control group used "minimum information" keys. The study also related the value of each type of key to the experience level of the user and to the nature of the subject presented. The experiments were conducted in a conventional (non-systems) setting and were not directed at the tactical military interpreter. They represent, however, the only known research effort dealing with specific aspects of the organization of keys. Decisions with respect to the following variations in image interpretation keys--now made wholly on a judgmental basis--should preferably be made on the basis of empirical findings:

Optimum size of the projected image.

Number of individual views to be presented on each slide, or on different slides showing the same object.

Aspect angle (vertical, oblique, ground).

The need for stereo pairs.

Inclusion of unconventional imagery (infrared, side-looking radar)

Preferred types of annotation (including identification, symbols, bar scales, etc.)

Number of different scales and image quality levels required for each keyed object.

Possible special formats for unconventional imagery.

Amount of text (including captions) required for each slide.

The possible increase in value by including color photographs and camouflage detection film.

PROBLEMS OF BULK IN REFERENCE STORAGE

The physical storage requirement of reference material may be a serious problem, depending on the nature of the installation--fixed or mobile--and the extent to which the system is automated. A fixed installation can obviously store much more material than a mobile system; and an automated system can store more data in chip form than a minimal system utilizing bound volumes. Reference information needs relative to the mobility of the system on the one hand and to automation on the other hand must be determined.

Manual Systems. Consider first the manual systems. There are a few multi-volume keys which have been characterized as too bulky, apparently with some justification. Recent efforts have reduced most military keys in common use today to one volume. A few have two volumes. Although a complete library of keys would indeed be large, an Army interpreter operating in a given area needs only a small fraction of the total store, perhaps a single regional key to the theater with which he is dealing, augmented by pertinent subject material. Many interpreters maintain individual desk files of materials they have found of special pertinence to their missions.

In the Army tactical setting, there are many small items which look much alike, differing only in minor details of configuration and dimension.

A recent survey of U. S. Army wheeled vehicles prepared by U. S. APRO image interpreters listed 25 different types in the limited range of 19 to 23 feet in length. Of these, 18 different types have a width of 8 feet, and the widths of all 25 types lie between 6.5 and 8 feet. Many interpreters probably would not be able to identify more than a small number of these vehicles without a key to refresh their memory on fine distinctions in configuration or dimensional data--for example, at a contact scale of 1 : 5000, a vehicle 20 feet long measures only .004 foot. Where the problem is to identify types of enemy equipment not seen before by the interpreter, pertinent keys of adequate coverage may be indispensable. In a static situation where the interpreter has already become familiar with most types of equipment appearing in the imagery, he may be able to operate faster without a key--and with equivalent accuracy. He would then resort to a key only when new items appear in the imagery to which he is assigned.

A fixed installation can presumably store an adequate library of interpretation keys. The problem reduces to selection of the most pertinent references for highly mobile systems. Pertinence is largely determined by the terrain and tactical situation in which the mobile facility is to be deployed.

In a training situation, an extensive library of keys may be necessary, but the question of available space in which to store them is less acute than in the field.

Ease of handling--and to some extent the degree to which a key is used--may depend on the type of binding used. The conventional binding of many earlier keys creates a page hump, hindering the use of the stereoscope. In comb bindings, the pages lie flat, and updating is facilitated. However, a special device is required to unlock the comb. A ring binder is preferable for field use, as the pages not only lie flat, but updating and purging is easily and quickly accomplished. No special device is required.

Automated Systems. Many military interpreters will in the future be integrated in automated image information processing systems of the type described by Mumbower and Richards (1962). Automated data storage and retrieval will be incorporated in such systems. Applicable key material, together with maps, charts, and other intelligence references, will be miniaturized and stored within the reference component. The Air Force Standard Chip System now includes interpretation keys. Therefore the 70mm diapositive film format must be considered for new keys. New format for "key chips" has been studied by HRB Singer under a contract from RADC, Griffins AFB, New York. The Defense Intelligence Agency is also interested in new formats for keys, but has not directed any specific type as yet.

In an automated system, information will be retrieved by use of a suitable code and projected for direct viewing and comparison with imagery being scanned. Required reference chips would be drawn from an extensive

central store. Obviously, preparing the reference store for such an advanced system will entail a massive initial effort of recompiling and updating existing material. When bound volumes are no longer used, the concept of consecutive pages will disappear. Each slide or film "chip" will stand alone. There should be no dangling ends of continuing text referring to previous chips or leading to subsequent ones.

The basic problem of bulk is to reduce volume while retaining the information required by the interpreter. The possibility should be explored that the keys required in a mobile Army situation can be sufficiently condensed and simplified that computer handling may not be necessary. A study could be made to determine whether there is need to mechanize the store of key materials for a given facility. Such a study would involve comparing simple keys (the "postage stamp" type where many small items are shown on a single page, for example) with more complex treatments to evaluate relative usefulness and effectiveness. Various techniques for miniaturization and display should be examined. The new family of teaching machines seems to have possibilities for displaying key materials from a reduced format.

Problem areas in automated reference storage and retrieval call for study of present and planned organization of keys, adaptation to automated storage facilities, and development of optimum methods for rapidly retrieving the stored materials and displaying them to the image interpreter.

QUALITY OF IMAGERY

Questions of the quality of imagery to be incorporated in keys merit separate consideration and would appear highly amenable to research. The present practice seems to be to include poor quality imagery only when examples of better quality are not available. Interpreters have complained of the poor quality of imagery in certain keys.

The assumption that all examples of imagery in keys should be of the highest feasible quality is open to question. If varying degrees of degradation were introduced to approximate operational conditions, the key might help the interpreter to achieve greater accuracy in his more difficult identifications. The problem could be approached through experimentation in which interpreter performance on a given sample of imagery is evaluated under "key" conditions ranging over a spectrum of quality. Variations in quality would represent degradation of acutance, tone, resolution, and contrast, or combinations of these characteristics.

When high quality imagery is desired for keys, recent refinements in the 300-line screen technique will produce illustrations which, even when reproduced in sizable numbers, retain an estimated 95 percent of the original detail. When dealing with extremely small tactical material, still higher reproduction fidelity is obtained by continuous-tone photocopy--a method which has been used successfully by the Army. However, the

relatively high cost of this method (approximately ten times that of photolithography) has prohibited its general use for large keys requiring wide dissemination. Limited photocopy editions have been used to supplement the lithographic versions. The photography seems to be generally preferred by image interpreters.

In adapting keys for use in automatic data processing systems, miniaturization and rear-view projection have introduced problems of reproduction. However, the high resolution inherent in new films has made it possible to reduce loss of image detail in miniaturization. Current microfilming techniques permit retention of a high degree of detail, especially when special low-contrast film is used.

A FRAMEWORK FOR EXPERIMENTATION ON REFERENCE KEYS

The present Research Study has approached the problem of references, and specifically image interpretation keys, in relation to an Army systems environment. A number of questions have been posed or suggested: In what circumstances does the use of keys contribute to the effectiveness of the information extracted from imagery? What kinds of keys are most effective for differing intelligence missions and objectives? How can the "key" concept be best incorporated in the design of image interpretation systems?

A wide variety of human factors problems requires solution in order to develop the best possible image interpretation keys. Based on the present study, these problems have been restructured in terms of three sets of variables relating to key development. The dependent variables--speed, accuracy, and completeness of interpretation--are the variables by which the output of the image interpretation system is measured. The independent variables in the first set presented are the conditions under which keys are used. The independent variables in the second set are variations in the keys themselves. The list has been developed as a basis for planning research studies designed to lead to the development of more useful imagery keys and improved procedures for maintaining and utilizing such keys.

FRAMEWORK FOR EXPERIMENTATION ON IMAGE INTERPRETATION KEYS

Independent Variables

Group I - Purpose and Environment

A. Use

1. Reference
2. Orientation
3. Training

B. Type of Facility

1. Fixed
2. Mobile

(these might be subdivided further into "forward" or "rear" areas)

C. Echelon of User

1. Army
2. Corps
3. Division
4. Regiment

D. Type of Imagery Interpreted

1. Vertical aerial photograph
2. Oblique aerial photograph
3. Panoramic aerial photograph
4. Ground photograph
5. Sidelooking radar
6. Infrared

E. Type of Terrain in Imagery to be Interpreted

1. Topography
   a. Flat
   b. Hilly
   c. Mountainous
   d. Swampy
2. Vegetation (cover)
   a. Open
   b. Partly wooded
   c. Thickly wooded
   d. Jungle

(other terrain descriptions may be added if necessary)

F. Geographic Area

a. Southeast Asia
b. USSR
c. Europe

(other specific or analogous areas may be added)

G. Reporting Requirements

1. Hot (spot)
2. Immediate
3. Mission Review
4. Detailed; Special; Summary

Group II - Key Materials Characteristics

A. Size

1. Single sheet
2. Single volume
3. Multi-volume
4. Punch-card
5. Disc
6. Film slide (chip)

B. Organization

1. Dichotomous
2. Integrated Selective
3. Essay
4. Regional
5. Subject
6. Item

C. Format

1. Method of Illustration
   a. Vertical photographs (stereo; non-stereo)
   b. Oblique photographs (stereo; non-stereo)
   c. Ground photographs
   d. Maps and charts
   e. Drawings and schematic diagrams; silhouettes
   f. Bar and other scales
   g. Annotations (various techniques)
   h. Text
   i. Captions
2. Method of Reproduction
   a. Direct photocopy (print; transparency)
   b. Lithography (screen)
   c. Microfilm
3. Quality of Reproduction
   a. All high quality
   b. Highest available quality
   c. Intentional examples of low quality
   d. Intentional degradation (simulated low quality)

SELECTED BIBLIOGRAPHY

NOTE: References are presented in chronological order to show the progression of contributions to image interpretation reference aids in their present form.

1952 American Society of Photogrammetry. Manual of Photogrammetry. 1952 Edition. Chapter XII, pp. 553-558.

Coleman, C. G., Jr. Naval Photographic Interpretation. Photogrammetric Engineering. Vol. XVIII, No. 3, pp. 486-489.

Colwell, R. N., Bradshaw, K. E., Smith, H. T. U., Thoren, R., and Von Drabbe, C. A. J. Report of Commission VII (Photographic Interpretation) to the International Society of Photogrammetry. Photogrammetric Engineering. Vol. XVIII, No. 3, pp. 375-451.

Frost, R. E. Discussion of Photo Recognition, Analysis, and Interpretation and Photo Keys. Photogrammetric Engineering. Vol. XVIII, No. 3, pp. 502-505.

1953 Rabben, E. L. Close Support Photo Intelligence for Ground Forces. Photogrammetric Engineering. Vol. XIX, No. 1, pp. 144-150.

Whitmore, F. C., Jr. The Dilemma of Military Photo Interpretation. Photogrammetric Engineering. Vol. XIX, No. 3, pp. 425-427.

1954 Hoffman, P. R. Interpretation of Radar Scope Photographs. Photogrammetric Engineering. Vol. XX, No. 3, pp. 406-411.

Department of the Army, Navy, and Air Force. Photographic Interpretation Handbook. TM 30-245, NAVAER 10-35-610, AFM 200-50, April 1954. Section IV, Photo Interpretation Keys, pp. 100-109.

PRECEDING PAGE BLANK-NOT FILMED

1955 Colwell, R. N. The Photo Interpretation Picture in 1955. Photogrammetric Engineering. Vol. XXI, No. 5, pp. 720-724.

Roscoe, J. H. Introduction of Photo Interpretation Keys. Photogrammetric Engineering. Vol. XXI, No. 5, pp. 703-704.

Simontacchi, A., Choate, G. A., and Bernstein, D. A. Considerations in the Preparation of Keys to National Vegetation. Photogrammetric Engineering. Vol. XXI, No. 5, pp. 582-588.

Waldo, C. E. and Ireland, R. P. Construction of Landform Keys. Photogrammetric Engineering. Vol. XXI, No. 5, pp. 603-609.

1957 Babington - Smith, C. Air Spy, the Story of Photo Intelligence in World War II. Harper, New York, 1957.

DeLancie, R., Steen, W. W., Pippin, R. E., and Shapiro, A. Quantitative Evaluation of Photo Interpretation Keys. Photo grammetric Engineering. Vol. XXIII, No. 5, pp. 858-864.

Seymour, T. D. The Interpretation of Unidentified Information--A Basic Concept. Photogrammetric Engineering Vol. XXIII, No. 1, pp. 115-121.

1959 Dill, I. H., Jr. Use of the Comparison Method in Agricultural Airphoto Interpretation. Photogrammetric Engineering. Vol. XXV, No. 1, pp. 44-49.

McDaniel, J. F. and Arntz, J. F., Jr. Aerial Color Film in Photo Interpretation. Photogrammetric Engineering. Vol. XXV, No. 4, pp. 529-533.

1960 Hoffman, P. R. Progress and Problems in Radar Photo Interpretation. Photogrammetric Engineering. Vol. XXVI, No. 4, pp. 612-618.

Olson, C. E., Jr. Elements of Photographic Interpretation Common to Several Sensors. Photogrammetric Engineering. Vol. XXVI, No. 4, pp. 651-656.

American Society of Photogrammetry. Manual of Photo Interpretation. 1960 Edition. 868 pp.

1962 Mumbower, L. E. and Richards, T. W. Image Information Processing for Photo Interpretation Operations. Photogrammetric Engineering. Vol XXVIII, No. 4, pp. 569-578.

Van Lopik, J. R. Optimum Utilization of Airborne Sensors in Military Geography. Photogrammetric Engineering. Vol. XXVIII, No. 5, pp. 773-778.

1963 Sadacca, R. Human Factors in Image Interpretation. Photogrammetric Engineering. Vol. XXIX, No. 6, pp. 978-988.

Bigelow, G. F. Photographic Interpretation Keys -- A Reappraisal. Photogrammetric Engineering. Vol. XXIX. No. 6, pp. 1042-1051.

Smith, J. T., Jr. Color--A New Dimension in Photogrammetry. Photogrammetric Engineering. Vol. XXIX, No. 6.

1965 Martinek, H. and Sadacca, R. Error Keys as Reference Aids in Image Interpretation. U. S. Army Personnel Research Office. Technical Research Note 153, 26 pp.

APPENDIX

DEFINITIONS RELATIVE TO PHOTO INTERPRETATION KEYS PROPOSED BY THE INTERSERVICE COMMITTEE ON PHOTO INTERPRETATION RESEARCH, KEYS, AND TECHNIQUES

PRECEDING PAGE BLANK-NOT FILMED

DEFINITIONS RELATIVE TO PHOTO INTERPRETATION KEYS
PROPOSED BY THE INTERSERVICE COMMITTEE ON PHOTO INTERPRETATION
RESEARCH, KEYS, AND TECHNIQUES

A photo interpretation key is reference material designed to facilitate rapid and accurate identification and determination of the significance of objects or conditions from the analysis of their photo images. Ideally, the key consists of two parts: (a) a collection of annotated or captioned stereograms and other photos which are illustrative of the objects or conditions to be identified and (b) a graphic or word description which sets forth in some systematic fashion the photo-recognition features of those objects or conditions.

Photo interpretation keys may be classified as to scope, technical level, intrinsic character, and manner of organization or presentation. Each of the following definitions is based upon the fundamental definition of a photo interpretation key, stated above.

1. SCOPE OF PHOTO INTERPRETATION KEYS

a. An item key is one concerned with the identification of an individual object or condition.

b. A subject key is a collection of item keys concerned with the principal objects or conditions within a given subject category.

c. A regional key is a collection of item or subject keys concerned with the identification of the principal objects or conditions characteristic of a particular region.

d. An analogous key is a subject or regional key which has been prepared for any given area and in which information is presented as to its applicability for the interpretation of objects or conditions in inaccessible areas having similar characteristics.

2. TECHNICAL LEVEL OF PHOTO INTERPRETATION KEYS

a. A technical key is one prepared primarily for use by photo interpreters who have had professional or technical training or experience in the subject concerned.

b. A non-technical key is one prepared primarily for use by photo interpreters who have not had professional or technical training or experience in the subject concerned.

3. INTRINSIC CHARACTER OF PHOTO INTERPRETATION KEYS

a. A direct key is one designed primarily for the identification of discrete objects or conditions directly discernible on photos.

b. An associative key is one designed primarily for the deduction of information not directly discernible on photos.

4. MANNER OF ORGANIZATION OR PRESENTATION OF PHOTO INTERPRETATION KEYS

All photo interpretation keys are based upon diagnostic features of the photo images of objects or conditions to be identified. Depending upon the manner in which the diagnostic features are organized, two general types of keys are recognized: "Selective keys" are so arranged that the photo interpreter simply selects that example corresponding to the image he is trying to identify. "Elimination keys" are so arranged that the photo interpreter follows a prescribed step-by-step process that leads to the elimination of all items except the one he is trying to identify. Where feasible of formulation, the latter type of key is considered preferable.

a. Selective Keys

(1) An essay key is one in which the objects or conditions are described in textual form, using photos only as incidental illustrations.

(2) A file key is an item key composed of one or more selected photo images together with notes concerning their interpretation, assembled by an individual interpreter largely for personal use.

(3) A photo-index key is an item key composed of one or more selected photo images together with notes concerning their interpretation, assembled for rapid reproduction and distribution to other photo interpreters.

(4) An integrated-selective key is one in which photo images and photo recognition features for any individual object or condition, within a subject or regional key, are so associated that by reference to the appropriate portion of the key the object or condition concerned can be identified.

b. Elimination Keys

(1) A disc key is one in which selected photo-recognition features are grouped or arranged on one or more discs so that when the recognition features are properly alined, all but one object or condition of the group under consideration are eliminated from view.

(2) A punch-card key is one in which selected photo-recognition features are arranged in groups on separate punch cards so that when properly selected cards are superimposed upon a coded base, all but one object or condition of the group under consideration are eliminated from view.

(3) A dichotomous key is one in which the graphic or word description assumes the form of a series of pairs of contrasting characteristics which permit progressive elimination of all but one object or condition of the group under consideration.